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ABSTRACT

This study tested the hypothesis that maternal drinking early in pregnancy affects the development of the child's central auditory processing. A follow-up study of 167 children took place 6 years after their mothers participated in a survey concerning health and drinking practices during the early stages of pregnancy. Indications of problem drinking (IPD) reported during early pregnancy were used as a measure of maternal alcohol use. Children were administered the Staggered Spondaic Word (SSW) test of central auditory processing, the Wechsler Preschool and Primary Scale of Intelligence, and the Token Test. Path analyses controlling for sociodemographic characteristics and maternal IQ indicated that IPD were negatively related to left-ear SSW scores, but were not related to right-ear scores. IPD had a significant indirect effect via left-ear SSW scores on Verbal IQ (VIQ) and Token Test scores, but not on Performance IQ. These results suggest that children of mothers who report two or more IPD early in pregnancy are at increased risk for problems in auditory perception, which may lead to the development of learning disabilities and a reduction in overall verbal functioning. (RH)

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Maternal Drinking Problems and Children's Auditory, Intellectual, and Linguistic Functioning

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Abstract

The present study tests the hypothesis that maternal drinking early in pregnancy affects the development of central auditory processing, which negatively impacts a child's intellectual and linguistic functioning. This study is a follow-up at age six of 167 children whose mothers participated in 1978-79 in a survey of health and drinking practices during the early stages of their pregnancy. Indications of problem drinking (IPD) reported during early pregnancy was used as a measure of maternal alcohol use. Children were administered the Staggered Spondaic Word (SSW) test of central auditory processing, the Wechsler Preschool and Primary Scale of Intelligence, and the Token Test. Path analyses controlling for sociodemographic characteristics and maternal IQ indicated that IPD was negatively related to left-ear SSW scores, but was not related to right-ear scores. IPD had a significant indirect effect via left-ear SSW scores on Verbal IQ (VIQ) and Token Test scores but not on Performance IQ. These results suggest that children of mothers who report two or more IPD early in pregnancy are at increased risk for experiencing problems in auditory perception which may lead to the development of specific learning disabilities, and a reduction in overall verbal functioning.

Many factors, such as intelligence, linguistic ability, and auditory functioning can affect learning (Sattler, 1982). These factors are subject to biological and environmental influences during the prenatal period and early childhood. Maternal substance abuse during pregnancy, the focus of the present investigation, has been identified as an important influence on development (Clarren & Smith, 1978; Little & Streissguth, 1981).

Deficits in perceptual functioning, such as hearing acuity and central auditory processing may interfere with the development of language (Katz & Illmer, 1972; Page, 1985). For children with loss of acuity, the ability to develop language varies directly with the magnitude of hearing loss. Children may, however, have normal acuity for the perception of sound but have problems in central auditory processing that preclude adequate understanding of linguistic information. These children may experience subtle learning problems that may remain undetected and result in sporadic loss of information or misinformation. During the early learning years, such processing deficits could contribute to reduced receptive language functioning and/or more global reduction in intellectual development. In later years, processing deficits may in turn effect higher-level cognitive abilities such as reading.

Drinking early during pregnancy, prior to pregnancy, and/or prior to pregnancy recognition has been associated with increased incidence of a number of developmental abnormalities, including speech and language deficits. For example, one follow-up of 63 patients with fetal alcohol syndrome reported that 46% were mentally retarded, and 80% had speech and language problems (Iosub, Fuchs, Bingol, & Gromisch, 1981). In another study, a higher than expected rate of heavy drinking during pregnancy was found in mothers of

children referred for follow-up of learning problems and hyperactivity (Shaywitz, Cohen, & Shaywitz, 1980).

We hypothesize that prenatal neurological development is compromised by maternal drinking, negatively affecting central auditory processing. Deficits in central auditory processing are, in turn, expected to have a negative impact on intellectual and linguistic functioning. For the present study, the resulting model, illustrated by Figure 1, was tested using path analysis.

Method

Subjects and Procedures

In 1978-79, a systematic sample of 547 obstetric patients at five sites in Buffalo, New York participated in the Women's Health Survey. Participants completed a self-administered questionnaire on their alcohol and drug use prior to recognizing pregnancy, indications of problem drinking, and sociodemographic characteristics. In 1984-85, a follow-up was conducted on 194 of these women and their children of the target pregnancy. The present analyses are based on 167 mother-child pairs.[1]

Children were tested at age six on standard measures of hearing acuity, central auditory processing and intellectual/linguistic functioning. While each child was being tested, his or her mother was interviewed in a room separate from her child. The mother's structured interview assessed present sociodemographic and family characteristics, and postnatal environment. Additional standardized measures included the Home Screening Questionnaire, a measure of richness of home environment (Coons, Gay, Fandal, Ker, & Frankenburg, 1981) and the vocabulary subtest of the Wechsler Adult Intelligence Scale (WAIS-R), as a measure of maternal intelligence[2]. The

interview and testing lasted approximately three hours, and participants were compensated $25 for their time.

Measures

Maternal alcohol use during pregnancy. Maternal indications of problem drinking (IPD) serves as a measure of maternal alcohol use during pregnancy in the present analysis (Russell, Cowan, & Czarnecki, 1987; Russell & Skinner, 1988). Eight questions were asked about behaviors that are significant indicators of problems drinking (e.g., blackouts, inability to stop drinking). Children were classified into two groups: those whose mothers had two or more problems (n=13) versus those whose mothers had no problems or only one problem (n=156). The interviewers and psychometrician were blind regarding group membership of mother and child.

Central Auditory Processing. Central auditory processing was measured using the Staggered Spondaic Word (SSW) test, a dichotic speech perception test (Katz, Basil, & Smith, 1963; Arnst, 1982). A spondee is a two-syllable word composed of two monosyllables which can stand alone as words, such as "upstairs" and "downtown". Each of the forty items on the SSW is composed of two spondees partially overlapped such that each ear receives stimuli both by itself and in competition with the other ear. For example, first "up" is presented to the right ear. Next, "stairs" and "down" are presented simultaneously to the right and left ears respectively. Finally, "town" is presented alone to the left ear. Items are counterbalanced as to which ear receives the stimulus first. The response given by the child is composed of four scores, representing percentage of errors on each syllable of the two spondees. For the present analyses, average right-ear and left-ear scores are

used. The right-ear score generally reflects decoding or understanding of auditory input, and the left-ear score reflects more complex processing involving the corpus callosum.

Intellectual and linguistic functioning. Intelligence was measured using the Wechsler Preschool and Primary Scale of Intelligence (WPPSI), which yields a Verbal Intelligence score (VIQ) and a Performance Intelligence score (PIQ).

Receptive language functioning was measured using the Child Token Test. (DiSimoni, 1978). Raw scores on the Token Test are transformed to a standard score scaled for a child's grade, with a mean of 500 and standard deviation of 5. Normal scores range from 495 to 505. Scores below 495 are considered inferior, and scores above 505, exceptional.

Potential confounders. To identify factors that might potentially confound the relationships among IPD, right and left SSW scores, VIQ, PIQ, and Token Test scores, six stepwise multiple regressions were performed. Each of these six variables was regressed on the set of maternal and postnatal/ environmental variables listed in Figure 1. Maternal vocabulary score, education, race, and HSQ were the only variables significantly related to one or more of the dependent variables. Based on these analyses, these four variables were considered potentially confounding factors in the path model.

Results

Analytic Strategy

Path analyses. Path analyses, performed according to standard procedures (Cohen & Cohen, 1983), were conducted for the three measures of intellectual and linguistic functioning, VIQ, PIQ, and the Token Test. For each analysis, maternal indications of problem drinking (IPD) was regressed on potential

confounders; left and right SSW scores were each regressed on potential confounders and IPD; and, finally, the dependent variables, VIQ, PIQ, and the Token Test scores were each regressed on potential confounders, IPD, and left and right SSW scores. Thus, the three models differ only at the final step.

Results of path analyses

Path coefficients are standardized regression coefficients taken from the above regressions in which the key variable for the path is dependent, e.g., coefficients for the paths between IPD and the potential confounders are taken from the regression in which IPD is regressed on the potential confounders. These path coefficients are summarized in the following models. Only paths significant at $p < .05$, two-tailed, are included.

Paths common to all models. None of the potentially confounding variables (race, vocabulary, and HSQ, and education) significantly predicted IPD. When controlling for potentially confounding variables, IPD was negatively related to left-ear auditory processing (Beta = -.21, $p < .01$), but was not related to right-ear auditory processing (Beta = -.03, N.S.).

VIQ

The model predicting verbal intelligence is depicted in Figure 2. Maternal intelligence has a direct effect on children's verbal intelligence, as do left and right SSW scores. Indications of problem drinking have an indirect effect on VIQ through left SSW scores.

PIQ

In contrast to the above model, maternal intelligence and race both directly influence PIQ scores, as do right ear SSW scores (Figure 3). Indications of problem drinking has neither a direct nor indirect effect on

PIQ.

Token Test

The model predicting Token Test scores is depicted in Figure 4. None of the potential confounders predicts children's performance on the Token Test. Both left and right SSW scores are, however, directly related to the Token Test scores, and IPD is indirectly related through left SSW scores.

Discussion

Influence of IPD on Central Auditory Processing and Outcome Measures

Maternal IPD exerts a small but significant indirect effect upon VIQ and Token Test scores that is mediated through auditory processing of input to the left ear. This effect can be interpreted as a mean reduction in test scores. Thus, the mean VIQ of children whose mothers have two or more IPD is .8 point lower than other children. Although this effect appears small, it implies a shift in the normal distribution of VIQ, thereby increasing the number of children in the abnormal range of intellectual potential, and decreasing the number of children in the superior range.

The relationship between increased IPD and left-ear scores on the SSW, together with lack of a relationship between IPD and right-ear scores suggests that alcohol may affect complex auditory processing that takes place in the corpus callosum. Neuropathological studies have, in fact, identified absent or underdeveloped corpus callosum among the disorders found in children whose mothers abused alcohol during pregnancy (Clarren, Avord, Sumi, Streissguth, & Smith, 1978; Peiffer, Majewski, Fischbach, Bierich, & Volk, 1979).

Regardless of its origin, however, reduction in auditory processing has several important implications. First, deficits in auditory processing form the basis of one etiological theory of the development of learning disabilities (Kavale, 1981; Wepman, 1975). In terms of specific learning disabilities related to auditory processing, research has shown that the ability to analyze spoken words into their components are among the skills critical to learning to read (Rosner, 1973). Thus, a child demonstrating poor auditory processing at age six may be at increased risk for experiencing specific learning disabilities, such as reading.

Second, children who obtain abnormal scores on the SSW test are likely to experience significant difficulty listening to speech in a background of noise (Katz, 1982). Therefore, the negative effect of maternal IPD on auditory processing suggests that children of mothers who report two or more IPD are at greater risk for experiencing this difficulty. Speech/noise difficulty may be experienced as an inability to concentrate in noisy environments, such as crowded school rooms or open classrooms. These children may lag behind their peers in school, and once behind, may find it increasingly difficult to catch up. If identified, however, children with this difficulty can be desensitized to the effects of background noise.

Influence of Potentially Confounding Variables.

As would be expected, maternal intelligence had a strong direct influence on VIQ and PIQ. When maternal intelligence, maternal education, and richness of home environment are controlled, however, the racial bias of the WPPSI reported in the literature remains for Performance IQ, but differences in Verbal IQ disappear (Kaufman, 1973).

Influence of Auditory Processing and IPD on Outcome Variables

The significant direct effect of SSW scores on VIQ, PIQ, and Token Test scores reflects the importance of central auditory processing in linguistic functioning. Specifically, the association between auditory processing of input to the right ear and results on all three outcome measures highlights the role of decoding auditory information in achievement on these tests. In particular, scores on the PIQ subtests, which typically measure visuospatial skills, are mediated considerably by the ability to decode verbal instructions that accompany the tasks.

In contrast, left-ear SSW scores significantly influenced scores on the VIQ and Token Test, but not PIQ. This association may reflect the more complex interhemispheric processes required in integrating auditory input to the left ear with material required for performance on expressive and complex receptive language tasks. The corpus callosum also plays a major role in integrating these functions.

Implications

The current estimate of learning-disabled children in the US is 7.5% (Karchmer, 1985), making identification and education of these children a major concern for the educational system. Early identification of children at risk for speech/noise difficulty and for specific learning difficulties may facilitate intervention early in a child's educational career, thereby mitigating potential effects on intellectual and linguistic development. Efforts at prevention, as well as effective remediation, must synthesize relationships between etiology and manifest disability. The present findings underscore the importance of developing prevention programs targeting women at risk for alcohol abuse during their child-bearing years.

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Author Notes

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Footnotes

1. Subjects were selected on the basis of alcohol exposure in utero estimated from maternal alcohol consumption in the month prior to pregnancy recognition. Children who were heavily exposed were matched on age, sex, race, mother's parity, SES, and marital status to children who were lightly exposed. On this basis, 338 mother/child pairs were eligible to participate. Of these, 104 (31%) were never located. Another 40 (12%) potential subjects were located but were not included because the children were too old, had died, did not speak English as their primary language, were used as a pilot subject (n=15, 4%), or the mothers either refused to participate or repeatedly did not keep scheduled appointments (n=25, 7%). Given the number of subjects in each category who were eligible for the study, rates of participation were slightly higher for light drinkers (62%) compared to heavy drinkers (53%).

A total of 194 children were included in the follow-up study. Twenty-seven children were excluded from the present analysis due to medical problems or because English was not their primary language (n=9), reduced hearing acuity that precluded participating in dichotic listening tests (n=9), or because of missing data (n=9).

2. When compared to the ten other WAIS-R subtests, Vocabulary has the highest split-half reliability (.94-.96 acaross all age groups), has the greatest test-retest reliability (r=.93) and is the single best predictor of Full Scale IQ (r = .83) (Wechsler, 1981).

Figure 1

Model of Alcohol Effects on Children's Auditory, Intellectual, and Linguistic Functioning

Potentially Confounding Factors

Maternal Characteristics

- Intelligence
- Race
- Education

Psychoactive drug use

Smoking

Postnatal & Environmental Characteristics

- Richness of home environment

Sex

Birth order

Household Configuration (presence of father figure, ratio of dependent to independent household members)

- Significantly related to one or more of the study variables

Independent Factors

Maternal Alcohol Use During Pregnancy

Mediating Factors

Central Auditory Processing

Dependent Factors

Intellectual and Linguistic Functioning

Figure 2

Predicting Verbal Intelligence

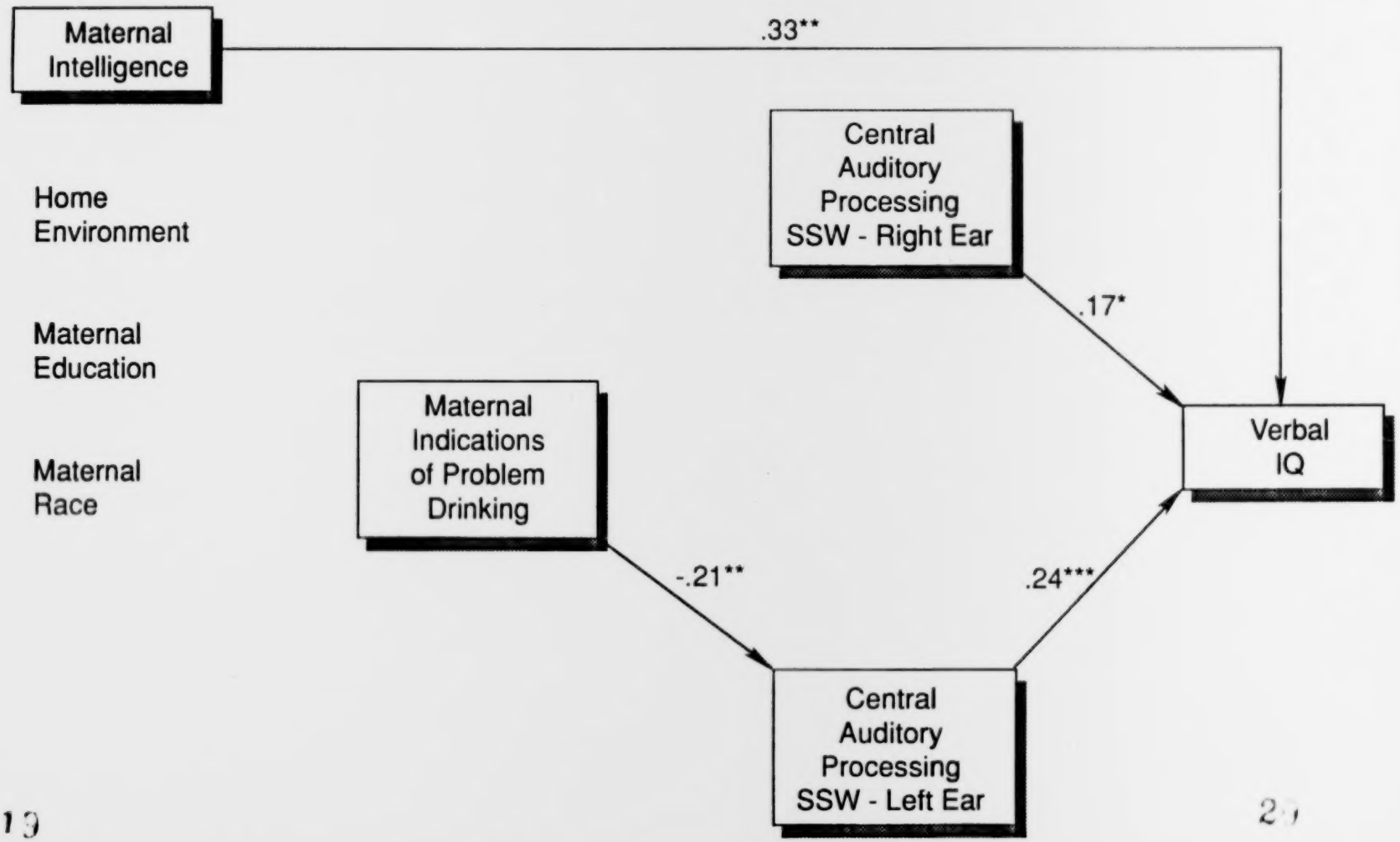


Figure 3

Predicting Performance Intelligence

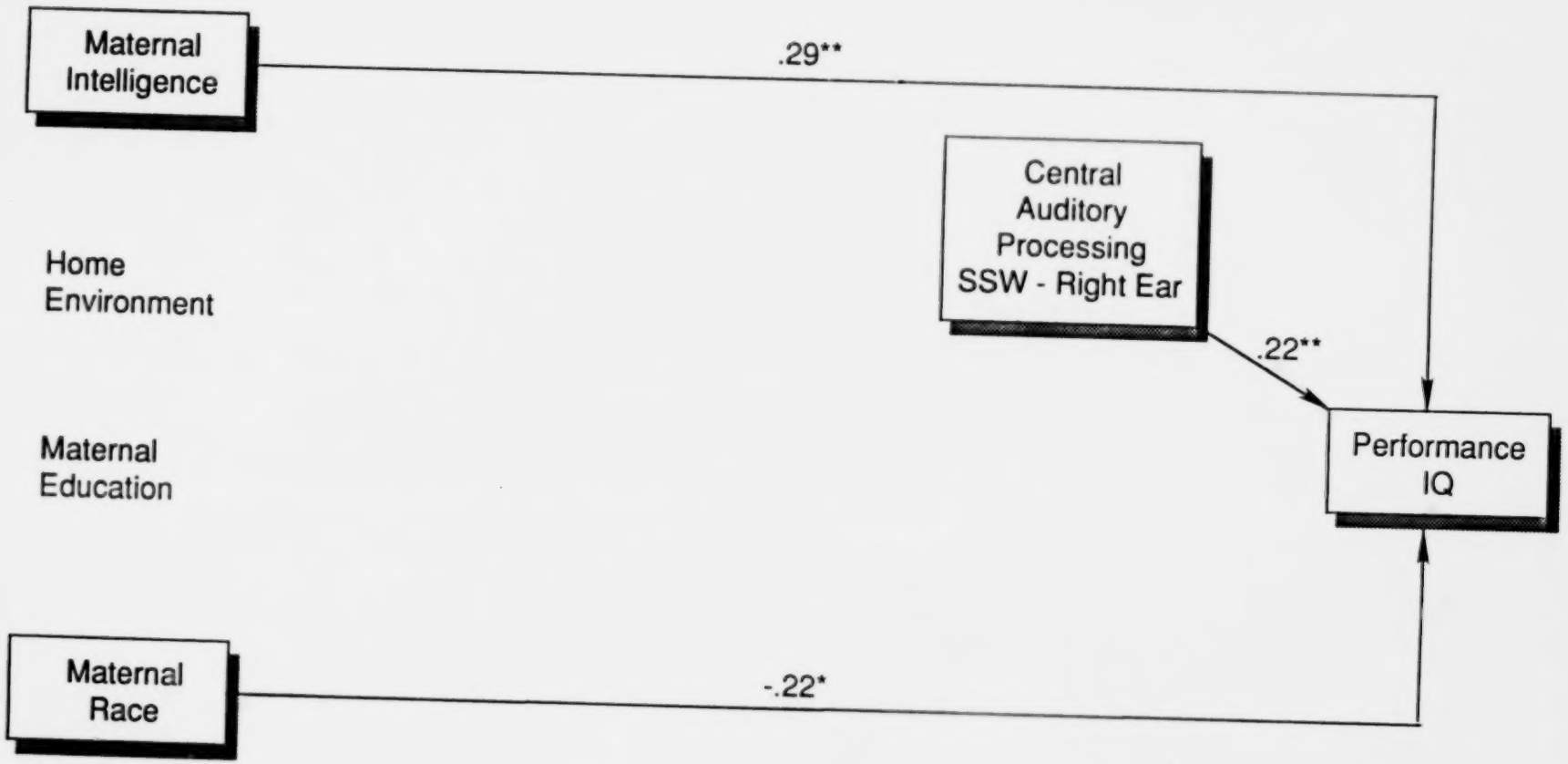
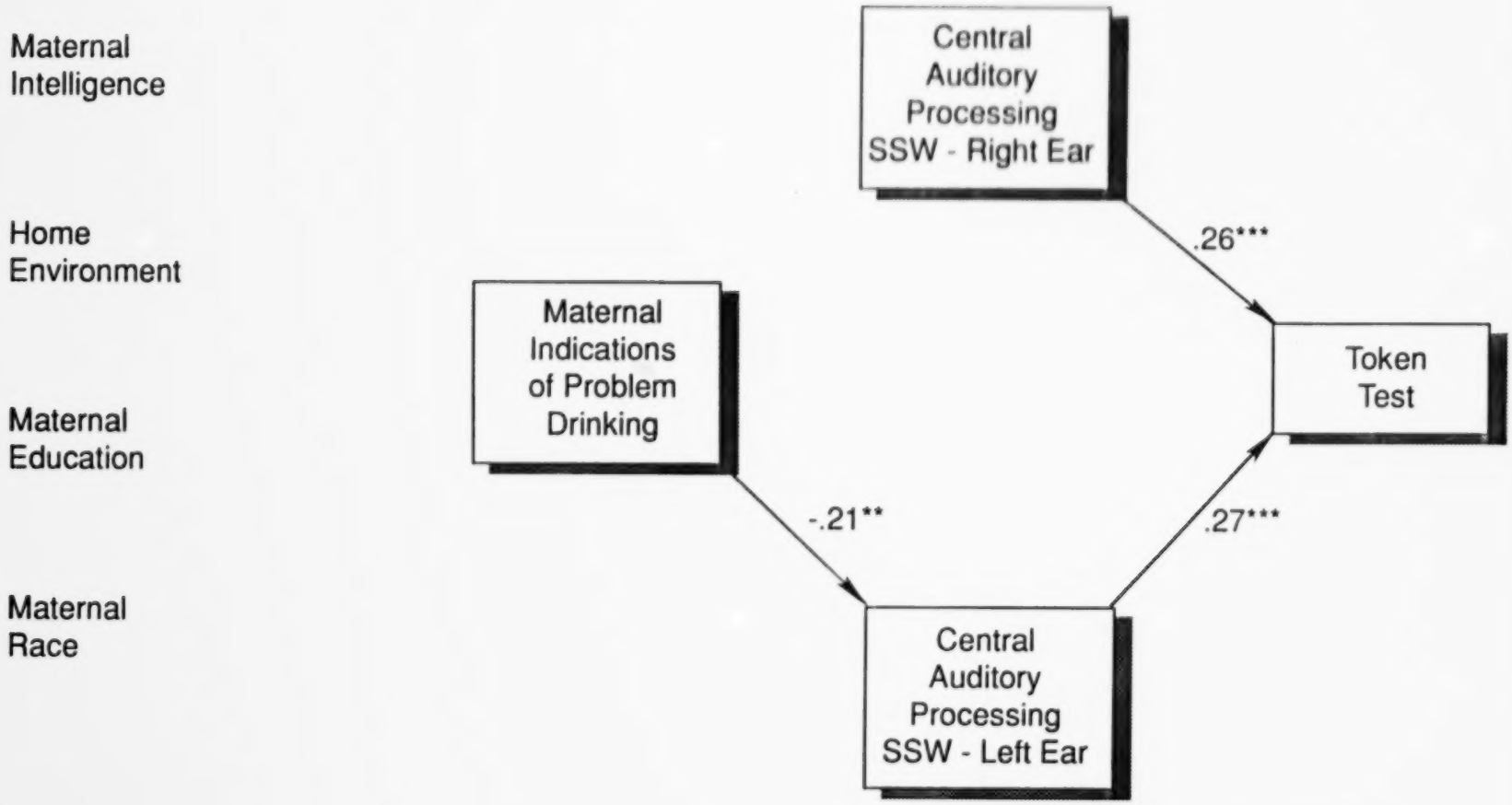


Figure 4

Predicting Receptive Language Ability



KEY	
*	p<.05
**	p<.01
***	p<.001